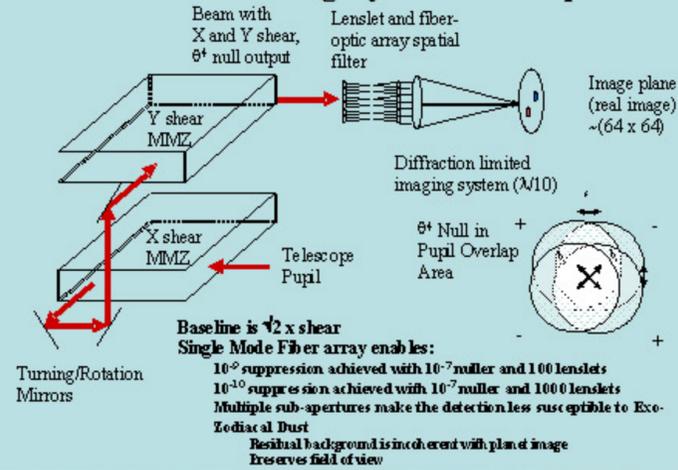


The Visible Nulling Coronagraph--Progress Toward Mission and Technology Development



Michael Shao, B. Martin Levine, J. Kent Wallace, and Duncan Liu
 Jet Propulsion Laboratory/California Institute Of Technology, Pasadena CA

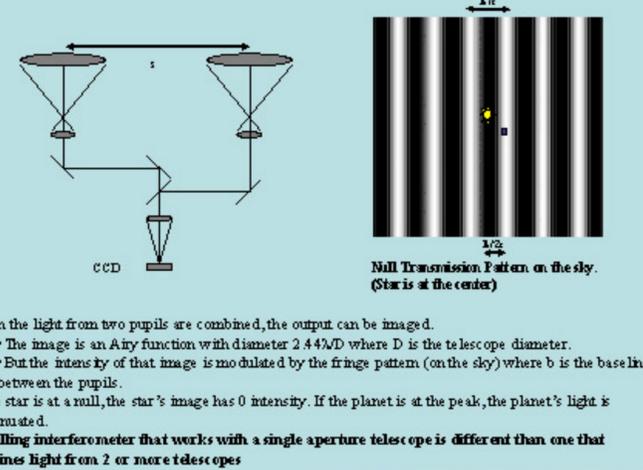
Visible Nulling System Concept



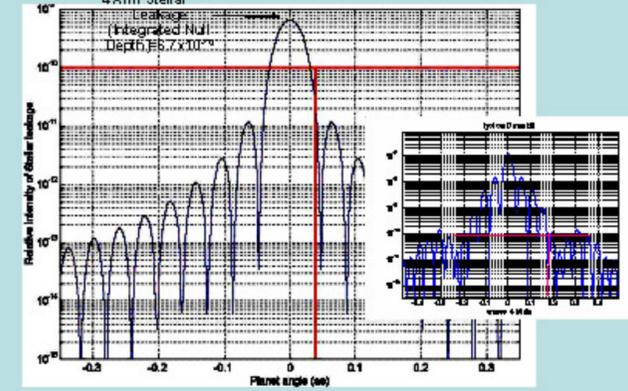
Why Another Coronagraph Concept?

- A modest sized aperture telescope can resolve an extra-solar planet and collect sufficient amount of light
 - Jupiters at 10 pc $D > 0.3m$ ($\lambda = 0.75\mu m$)
 - Earths at 10 pc $D > 1.5m$
 - The HST (at 2.4m diameter) is capable of imaging $m_p = 30$ stars
- The major issue is overcoming the contrast between star and planet (10^{-9} - 10^{-10}) (10^{-9} for exo-Jupiters)
- Nulling interferometer/coronagraph belongs in a class of small inner working distance devices
 - Use 4-5m class telescopes (less expensive than larger telescopes).
- The nulling coronagraph is (Orders of magnitude) easier to control scattered light, at the required contrast of 10^{-10} per airy spot
 - Amplitude, Phase, Spectral Bandwidth, and Polarization Controls
 - Concept Heritage from:
 - Bracewell and McPhie (Nulling Interferometer)
 - Shao (Hubble Extra-Solar Planet Imaging)
 - Angel, Angel & Woolf (Large Telescopes, Nulling Interferometers)
 - The Nulling Interferometer is the Enabling Technology
 - Heritage from SIM Nulling
 - The Fiber-optic Spatial Filter is Enhancing Technology
 - Uses Telecom & AO components

Imaging with a Nulling Interferometer

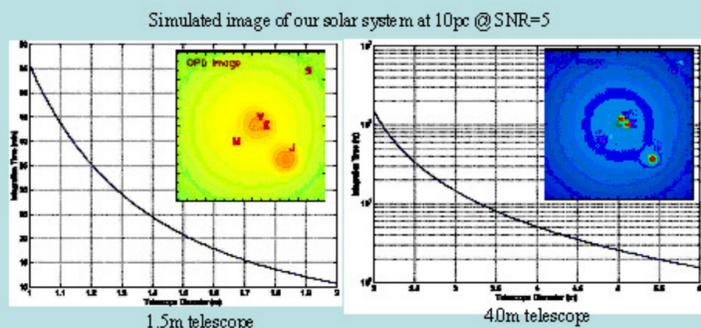


Ideal performance of Visible Nulling Coronagraph



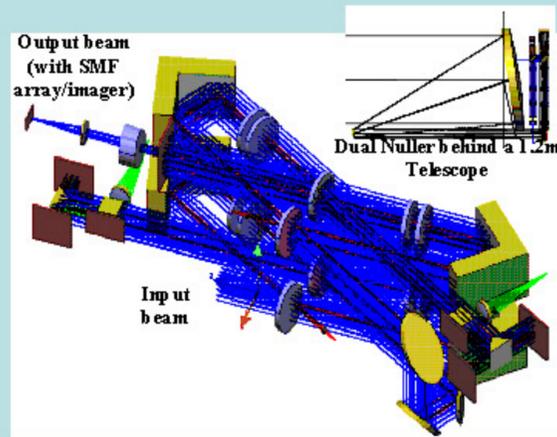
Four-arm interferometer leakage below 10^{-10} at $\theta \sim \lambda/D$

Imaging Simulations, Integration Time & Telescope Diameter

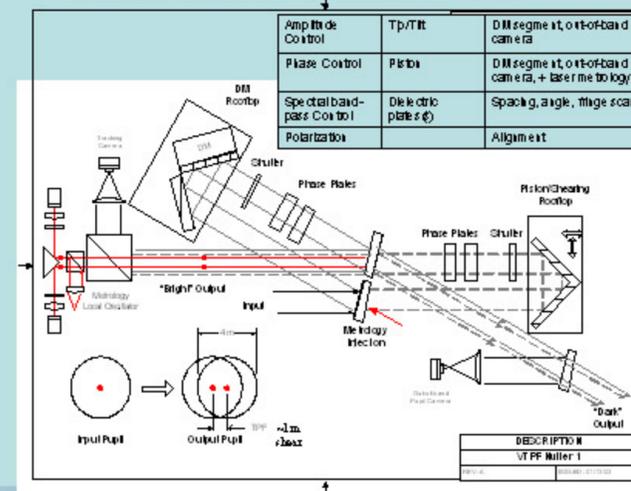


- Nulling coronagraph architecture changes requirement that large apertures are required for TPF science

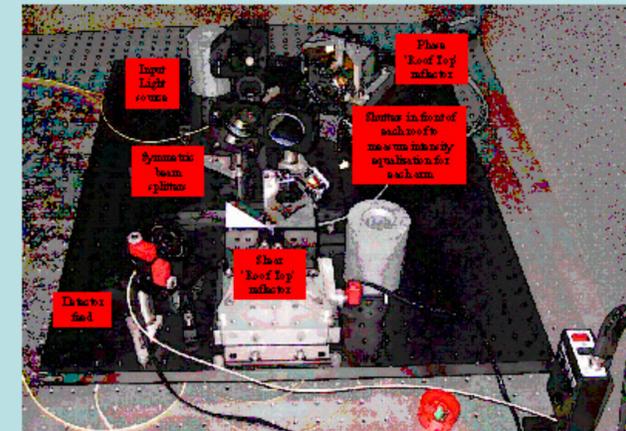
Dual Nuller Flight Instrument Configuration



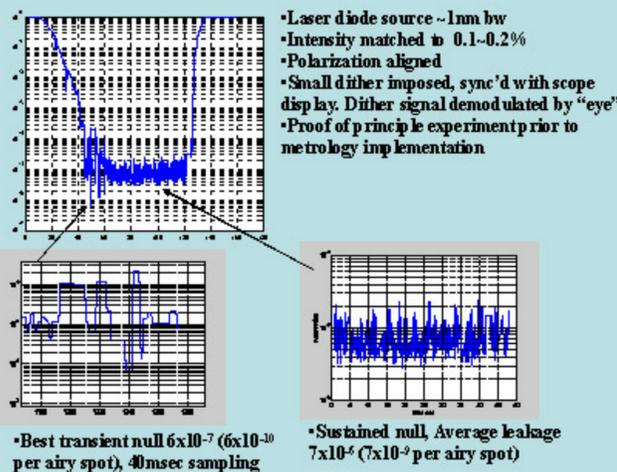
Nuller #1 with Control Points



Proof of Concept Nulling Interferometer Demonstration

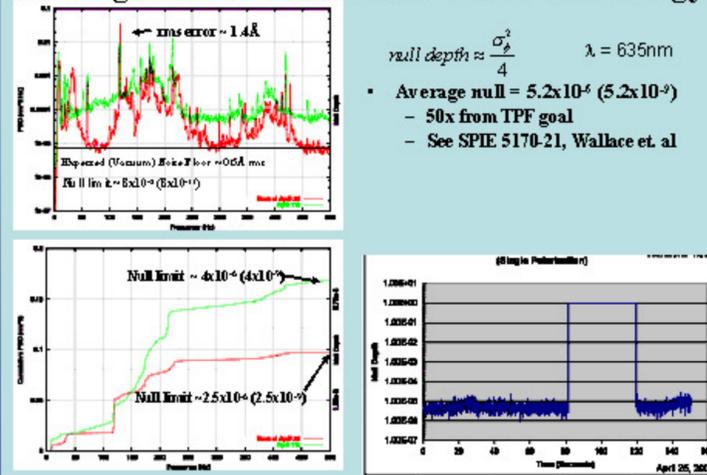


Deep Nulls from Monochromatic Light



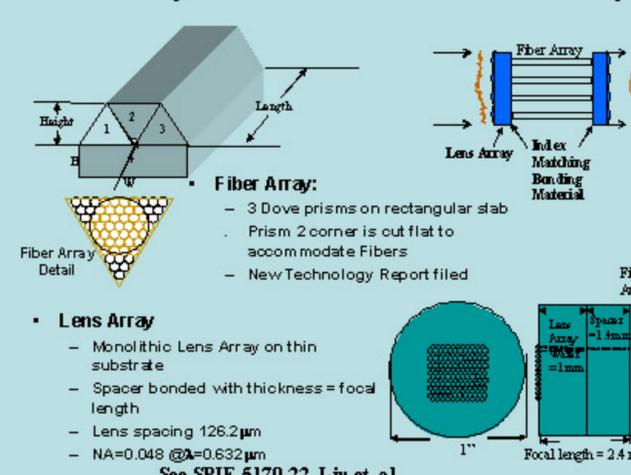
- Laser diode source ~1nm bw
- Intensity matched to 0.1-0.2%
- Polarization aligned
- Small dither imposed, sync'd with scope display. Dither signal demodulated by "eye"
- Proof of principle experiment prior to metrology implementation

Nulling Performance under Laser Metrology



- Null depth $\approx \frac{\sigma_p^2}{4}$ $\lambda = 635nm$
- Average null = 5.2×10^{-6} (5.2×10^{-9})
 - 50x from TPF goal
 - See SPIE 5170-21, Wallace et al

Self Assembly of Fibers in Coherent Array



Single Mode Fiber Array Construction

